CHAPTER 11 - GROWTH MODEL, YIELDS, SUGGESTED REGIMES

Data Collection

Forest Research has been measuring a large number of PSPs throughout New Zealand for many years. Since 1990, the measurement programme has included regime trial plots. To evaluate the blackwood PSP data, appropriate data has been used to develop a preliminary blackwood growth model that can be used to predict managed blackwood growth in New Zealand.

Site Indices

Blackwood will tolerate a wide range of soils, but growth across sites is known to be variable. Interim site indices have been developed, which suggest a height range from 15 to 45 m at a base age of 30 years (Fig 54).

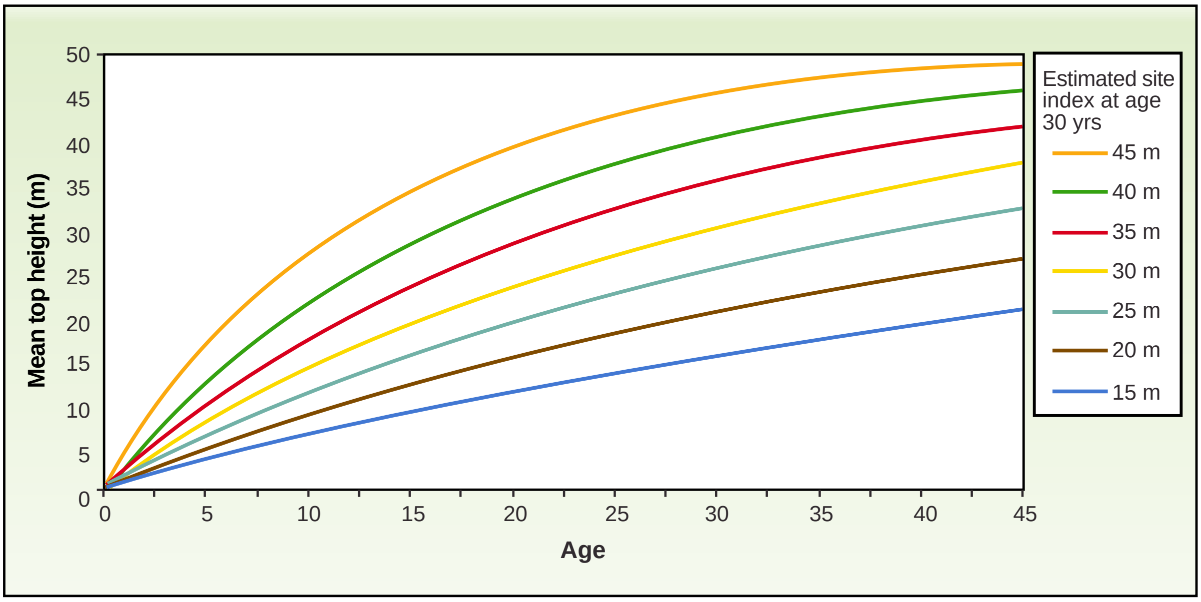

Figure 54: Site index curves

Volume

Volume and taper equations that estimate stem volume have been developed for blackwood. These were based on a sample of 43 trees from a 21 year-old stand from Hunua Forest, and 13 trees from a 12 year-old stand near Rotorua. The taper equations, calculated in 1992, were labelled preliminary until more data was available to cover a wider range of silviculture and sites.

Forest Research Preliminary Growth Model

To test the model, data from one site (the mean of five plots measured from age 5-17 years) was used as a starting point. This site has a mean Site Index of 35.1 m (estimated MTH at 30 yrs). Three scenarios were tested: no thinning from initial plot data (630 stems/ha), current management (thinning down to 160 stems/ha) and the proposed blackwood regime, thinned to 400 and 200 stems/ha (see later in this chapter). Actual data was also included in the graph (Fig 55).

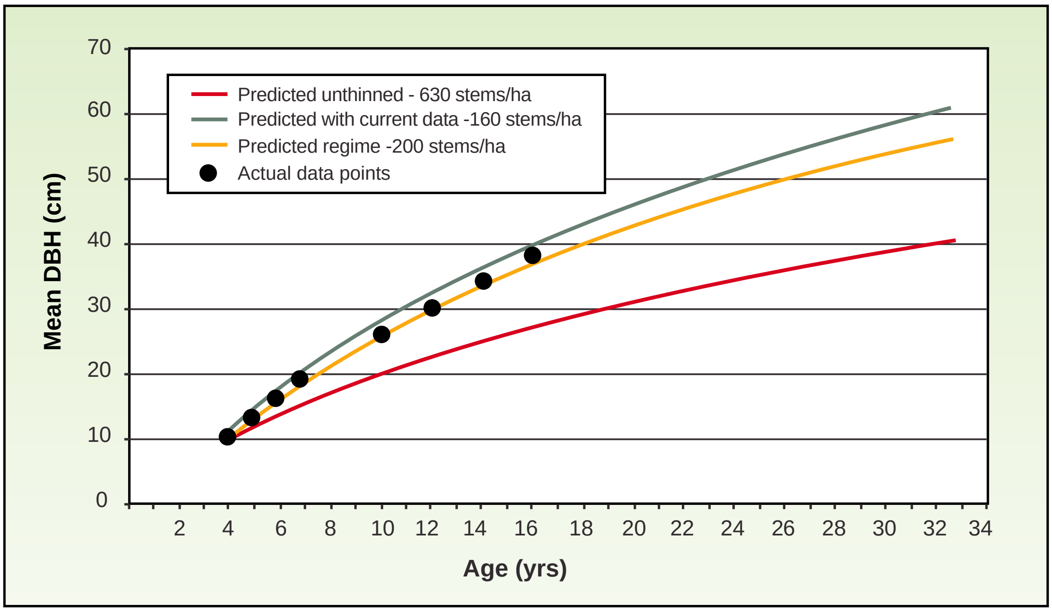

Figure 55: Model predictions of diameter growth at one site testing three regimes

The predictions shown in Figure 55 clearly show reduced diameter growth in an unthinned blackwood stand. This trend is also supported by recent measurements in a 41 year-old stand. The predictions, based on 160 stems/ha using age 5 starting information, suggest a 62 cm diameter at age 34. The model predicts that carrying 200 stems/ha brings mean diameter to 57 cm at age 34. The actual data collected indicates the model is predicting diameter growth reasonably well. The predicted volume difference between 160 and 200 stems/ha is 24 m3/ha in favour of the higher stocking. Although the unthinned has a much higher stand volume, much of the volume would be represented by very small logs. The mortality function in the model also reduced the stockings of 160 and 200 stems/ha down to 128 and 158 stems/ha respectively. It must be stressed that using age 5 data as a starting point may lead to errors in the predictions in an example like this. More model interpretation is required to better understand the silvicultural options. The preliminary model is yet to be released.

Growth Model

Data

The Forest Research blackwood dataset contains a total of 1722 measurements from 229 plots that were considered appropriate for growth modelling (Table 7). Functions that predict mean top height, basal area, mortality, post-thinning basal area, initial basal area and volume have been included in the model.

Table 7: Blackwood growth modelling data summary. Mean annual volume increment (MAI) statistics calculated from maximum MAI for each sample plot.

	Age (years)	**Stocking** (stems/ha)	**Mean top height** (m)	**Basal area** (m^2/ha)	**Volume** (m^3/ha)	**Volume MAI** (m^3/ha/yr)
Mean	9.2	788	9.1	8.6	42.9	5.23
s.d.	5.5	744	5.2	9.3	69.0	4.24
min.	3.0	20	2.1	0.0	0.1	0.136
max.	34.0	6000	31.8	55.4	462.2	21.09

Blackwood managers should establish permanent, or temporary plots, within stands to derive better starting data for model runs.

While much of the data came from pruned stands, the effects of clear bole pruning on growth rate are not modelled explicitly. Therefore, the effect of pruning on growth rate is considered implicitly (by default) in the model.

The model can be employed to derive the appropriate approximate rotation length and final crop stocking for an approximate target piece size or *vice versa*. However this does assume that basal area starting data are appropriate to the site. If starting basal area data are too low, analysis of model predictions may favour an excessively low final crop stocking to achieve a given diameter and rotation length; such a regime may underutilise the available growing space.

The model predicts a mean diameter which will be exceeded by the larger stems, but provides a useful indication of piece size in the absence of a diameter distribution model.

Throughout the development of the model, in particular during basal area and thinning response function development, it became apparent that heavy thinning was often followed by a period of greatly reduced basal area growth, presumably at the expense of crown development to occupy canopy gaps created by thinning. Needless to say, this 'lag phase' is effectively adding to the rotation length, and in theory could be reduced through the adoption of a more conservative, progressive thinning regime. It is not known whether the additional cost of repeated stand entries (to effect more frequent lighter thinnings) would be outweighed by the significant economic advantage of rotation length reduction. The reduction of rotation length is particularly important from the perspective of a discount cashflow analysis over the relatively long rotation lengths predicted for all but the lowest blackwood final crop stockings.

Yields - MARVL

While New Zealand sample plot data and the growth model use taper and volume equations to predict total stem yields, information on actual merchantable yields from plantations is scarce. To estimate recoverable yields some initial research using MARVL (Method of Assessing Recoverable Volume by Log type) has been undertaken.

A number of PSPs have been assessed using the MARVL technique. This system recognises the potential of stands to yield different products, if crosscut using different log selection criteria. A sample of standing trees is assessed and the stem qualities of the trees are recorded. The effect of crosscutting these trees to a set of log product specifications is then analysed by MARVL software, in such a way that the optimal value is recovered from each merchantable stem.

In the stands assessed, trees were described as swept or straight, as well as the following codes:

- Pruned or naturally unbranched stem
- Sawlog with branches <7cm in diameter
- Sawlog with branches >7cm in diameter
- Pulp
- Fork
- Waste (rot, malform, excessively large branch)
- Unmerchantable (including dead standing)

All live trees in the plots were assessed using Forest Research taper and volume functions derived specifically for blackwood.

From the MARVL analysis of two contrasting stands it is apparent that:

- There was wide variation in yield between different silvicultural systems.
- Retention of a high stocking rate will result in a significant proportion of small diameter logs.
- Large diameter is important, especially SED.
- The emphasis should be on butt logs rather than top logs which produce little quality sawlog material.

Figure 56: Overstocked stand used in MARVL inventory, note variable diameters, and high crowns.

Example One

41-year-old overstocked stand, Figure 56

This stand had reduced from 800 stems/ha to 500 through natural mortality. This occurred between age 27 and age 41, when the MARVL inventory was undertaken. A range of minimum SED options was evaluated. In all strategies assessed, the firewood component or non sawlog material was almost half the standing volume, especially when larger minimum SEDs were specified (Fig 57). In all scenarios, cutting waste also provided a large source of residues.

Sawlog SED was also critical to the outturn of the stand. As an example, with the many assumptions in the analysis, an SED of 200 mm compared with one of 300 mm improved nominal stand values from nearly $21,000/ha to nearly $34,000/ha. Increasing the best quality sawlog price, (although firewood values were reduced) increased these values to nearly $25,000/ha and to nearly $40,000/ha. However, the current market in New Zealand will not accept logs with these SEDs. The lowest nominal value scenario was from an SED of 400 mm. This indicates that the current high stocking has significantly reduced the value of acceptable sawlogs (>40 cm SED) (Fig 58).

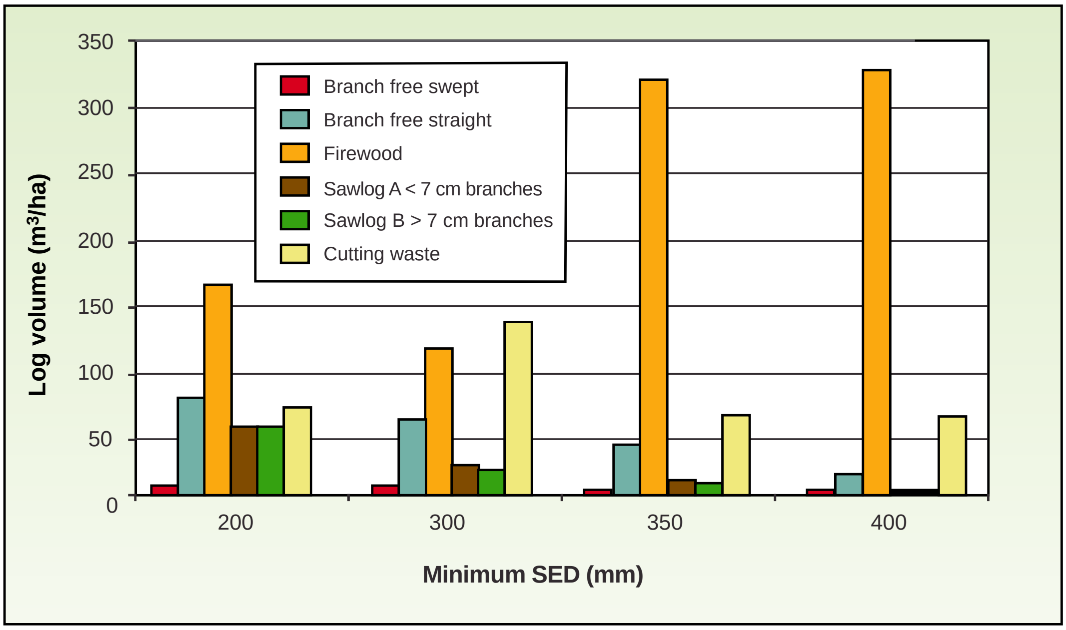

Figure 57: MARVL log volume summary of products by SED group.

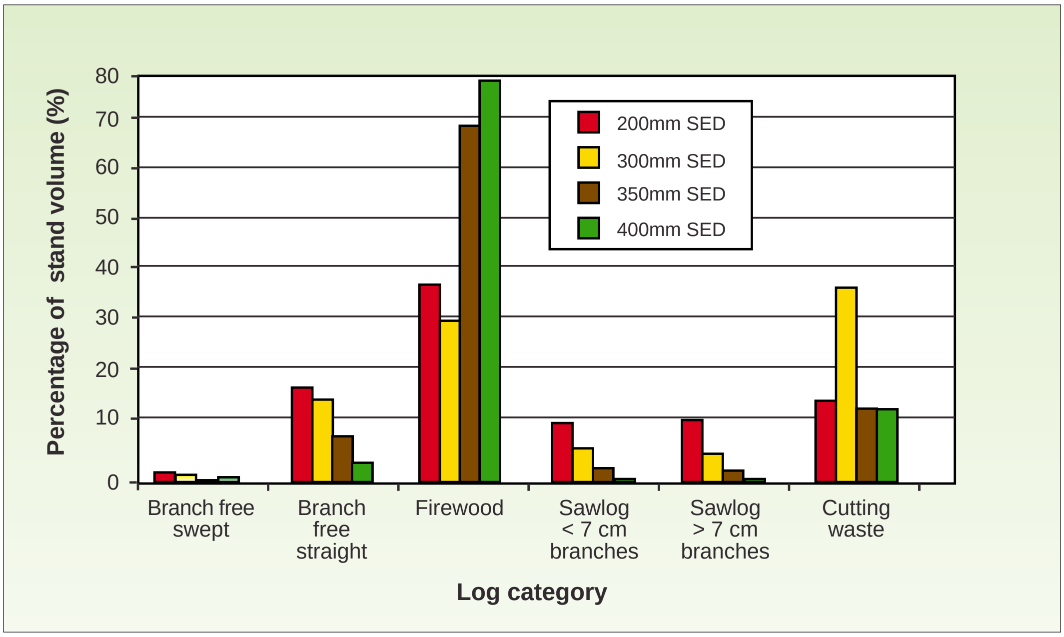

Figure 58: MARVL percentage of stand volume of products by SED

Figure 59: Well managed stand used in MARVL inventory, note photo taken at age 15 years. (Whangarei)

Example Two

17 year old well-managed stand, Figure 59

Five plots were assessed within a 17 year-old stand. This stand was well managed and could be considered typical of well tended blackwood in New Zealand, but well short of rotation length (Figs 60-62).

These MARVL assessments highlight the inherent problem with growing blackwood as a timber tree. Above the pruned butt log there is little sawlog material of any consequence, and most of the top logs, at this very young age, are classified as firewood material.

As can be seen in Figure 62 there is considerable variation between plots, largely as a result of stocking. The best performing plot for pruned log material (Plot 6) is at 150 stems/ha compared with the poorest at 90 stems/ha. It is interesting to note that Plot 2 at 170 stems/ha does not produce the volume of Plot 6, thus stocking alone does not reflect the volume of final log grades. This highlights the need to maintain and improve the current data base before conclusions can be reached on the best blackwood regimes.

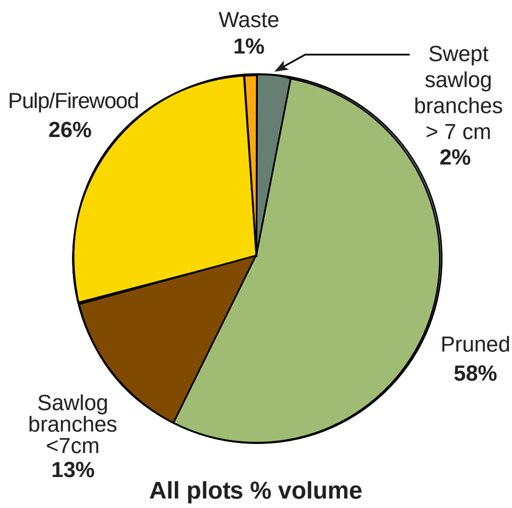

Figure 60: MARVL data, combined plots summary of grade outturn as percentage of volume.

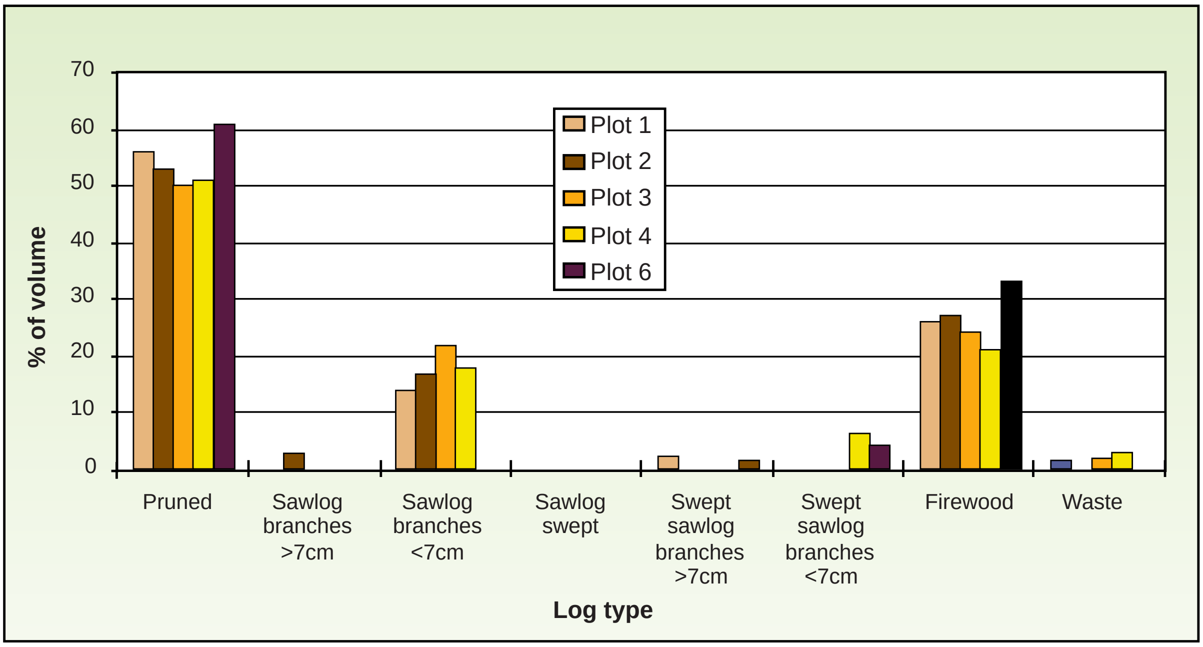

Figure 61: MARVL data as a percentage of volume by log type per plot.

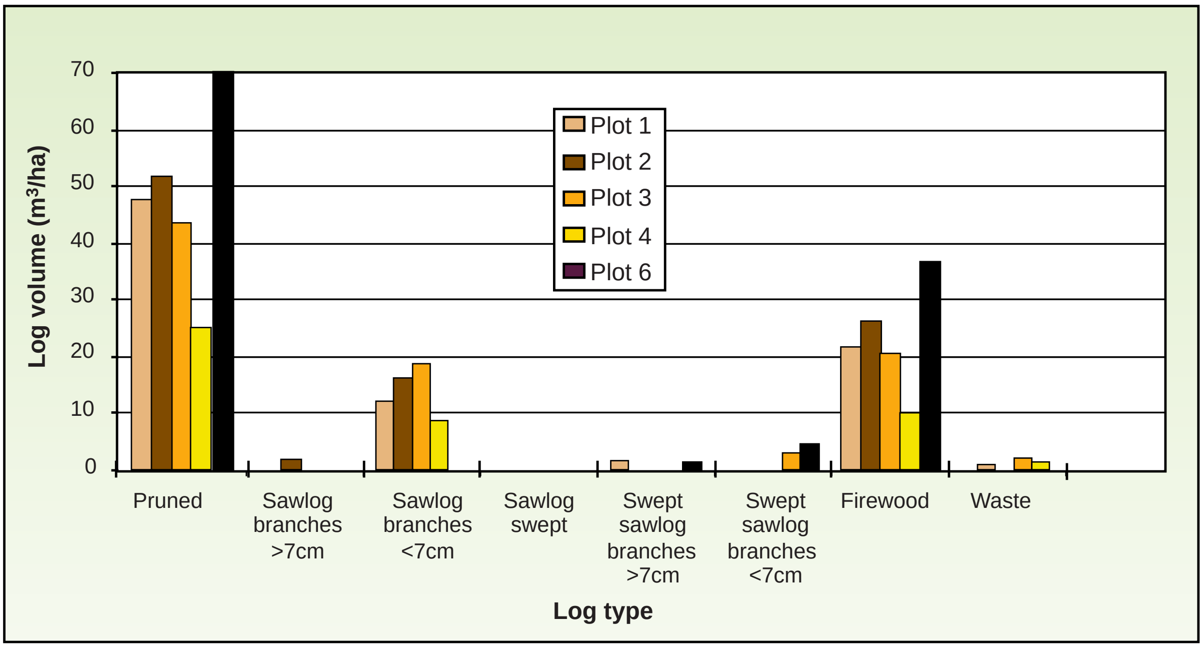

Figure 62: MARVL data of log volume output by plot.

Assessing recoverable yields in blackwood plantations

The potential of plantation blackwood (*Acacia melanoxylon* R. Br.) to produce sawlog material is accepted, but the estimated recoverable yields from plantations is less well documented.

To increase the understanding of recoverable yields, 24 plots of 18-year-old tended blackwood across four sites were evaluated using MARVL (Method of Assessing Recoverable Volume by Log type), and evaluated using computer software (Atlas Cruiser), to assess recoverable yields for a number of scenarios for both the original data and for the stand grown on to tree pieces sizes expected at clearfelling. Results of previous MARVL data from 17-, 25- and 35-year-old stands were compared with the new data collected.

The results show that for the mid-rotation data, stands were carrying nearly three-quarters of the total stand volume as a sawlog component. When the data for the 24 plots were 'grown forward' to simulate expected tree sizes at clearfelling the sawlog component was reduced to two-thirds. This supports published figures which suggests that a mature stand of blackwood will have 55-60%, or approximately 300 m^3/ha, of sawlog material. Comparison with the MARVL results from other stands at 25 and 35 years old suggest this simulated results are conservative, but data from rotation age stands will need collecting to verify this, as will further investigation of the functions used in this analysis to grow the crop forward. The levels of recoverable sawlog material were not very sensitive to log prices of the prime butt logs.

This study has shown that pruned stands produce around 40% of high-quality, pruned butt-log material, as well as 20-30% of branched sawlog material. This refutes the perception that blackwood is a butt-log species only, highlighting the fact that blackwood with a DBH of approximately 60 cm and approximately 38 m tall will produce a range of recoverable sawlog qualities. However, the best-quality material is in the butt log and emphasises the need for quality management and adequate pruning to maximise quality-log outturns

Source: Nicholas *et al.* 2006c

Suggested Blackwood Regime.

The following regime is one based on the authors' experiences and is their "best guess" in 2002. As more information is gathered, aspects of this could change and the regime modified. Therefore, the following regime should be treated as provisional and may be modified in the light of further experience and information.

The target is to produce a tree of 60 cm DBH with a pruned butt log of 6 m, at a final crop stocking of approx. 200 stems/ha. On reasonable blackwood sites, this should be achieved in 35-40 years (Figure 64).

The regime assumes a reasonable site and a commitment to form pruning.

Initial spacing: 800 stems/ha.

Form pruning: (leader training) should start from age 2 years and combine with *gauge pruning* using a 30 mm gauge from age 3 years, continuing on an annual basis until the 6 m butt log is formed (age 4-6 years depending on site conditions).

- Clear wood pruning: can start at age 4 years leaving 3 m green crown at each pruning lift. Two or three lifts may be required to produce a 6 m clear bole. These should be completed by age 7-10 years (depending on site conditions).

- Thinning: should start when crowns compete. First thinning to 400 stems/ha should occur at age 7-8 years, followed by a second thinning by 10 years to a final crop of 200 stems/ha.
- Yields: total stem yield will be approximately 500 m^3/ha, but sawlog recoverable yield may be only three quarters of the material. Therefore, a conservative estimate of 300 m^3/ha sawlog material may be appropriate. More information is required on these aspects.

Figure 63: Well managed stand 200 stems/ha, age 14 years. (Rotorua)

Stand evaluations

The quality of management information has been hindered by a lack of mature well tended stands to evaluate. Two stands established in 1967 were developed as thinning trials, both thinned with different approaches; one receiving a single thinning and the other managed under a multiple thinning strategy. The stands, in Hunua and Riverhead Forests, were assessed by their owners from 1978 and data collection has been continued by Forest Research since 1987. A detailed evaluation was performed in 1993 which included tree quality assessments as well as standard tree growth measurements. Interpretation of the data collected over 16 years has demonstrated that blackwood has responded to thinning, although mean top diameter has been little influenced in the stocking range between 192 to 1392 stems/ha. Growth between the two sites has also varied considerably. Tree quality measured as bole height to major leader defects was not influenced by stocking. A thinning trial from South Africa suggests a final crop stocking of 300 - 400 stems/ha. The New Zealand data from thinning trials and other PSPs lead to an interim recommendation for final crop stockings of at least 200 stems/ha.

Key Points

- A growth model for stand prediction has been developed, but is not yet available.
- Future model predictions should be reviewed and updated periodically, as more growth data becomes available.
- Site indices suggest that a range of MTH from 15-45 m at age 30 could be expected.
- Assessment of recoverable yield suggests large butt log diameters should be targeted.
- The regime is designed to produce a target tree of 60 cm DBH, pruned to 6 m with a rotation length of 35-40 years.
- An initial stocking of 800 stems/ha that receives form pruning, clearwood pruning by age 8 and thinning to 200 stems/ha by age 10 is recommended.
- Yields of 300 m^3/ha sawlog material is estimated.
- As more data is collected preferred regimes are likely to be updated, therefore seek up to date advice.

Suggested reading:

Berrill, Nicholas, and Gifford 2002.

Candy 1989.

Deadman 1990.

Nicholas 1983.

Nicholas 1988.

Pilaar and Dunlop 1990.

de Zwaan 1981.